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FLIGHT TESTING AS A DESIGN DRIVER

SESSION 15

Outline of panel presentation to be given at AIAA Session,
January 26, 1984, Anaheim, California

Weneth D. Painter
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NASA Ames Dryden Flight Research Facility

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The panel will present and discuss the interrelationship between the design of an aircraft and the flight test and how each impacts the other. The panel will view design and flight test from three different areas, flight research aircraft, military or weapons system, and commercial aircraft. The following are summaries of each panelist views on the subject:

1. Roger C. Crane, Deputy Chief, Avionics and Armament Division, Air Force Flight Test Center.

2. Philip F. Oestricher, Director, Flight Test, General Dynamics, Fort Worth Division.

3. James T. Johnson, 757 Chief Project Engineer, Boeing Commercial Airplane Company.

4. S. Lewis (Lew) Wallick, Jr., Director of flight Test, Boeing Commercial Airplane Company.

5. Mr. John A. Manke, Director of Flight Operations, NASA Ames Dryden Flight Research Facility.

6. Mr. Kenneth J. Szalai, Chief of Flight Support Division, NASA Ames Dryden Flight Research Facility.

Roger C. Crane
Deputy Chief, Avionics and Armament Division
Air Force Flight Test Center

V. ROGER C. CRANE, Deputy Chief, Avionics and Armament Division, Air Force Flight Test Center

A. INTRODUCTION

Government flight test and evaluation is a key element in the development of weapon systems. There are two basic types: Advance Development (AD) programs and production-oriented Development or Operational Test and Evaluation (DT&E or OT&E). Both of these types of Government flight tests are accomplished in much the same manner as private sector contractor flight tests, however, their function, at least in theory, is entirely different. All contractor flight tests are design or development oriented. Government flight tests are conducted to evaluate the performance of the contractor. In practice, the relationships between private industry and Government flight testing are much less distinct than these theoretical relationships. Regardless of the actual relationship, contractor-conducted flight testing can be a direct design driver whereas Government conducted flight tests drive the design of weapon systems in a more subtle, or less direct manner.

1. The private sector (contractors) is paid to: research, design, develop, demonstrate, and produce airplanes. The "product" can be technology (NASA), or a weapons system (USAF). The contractor is paid to produce.

2. The Government agency is tasked with the evaluation of the contractor's performance.

   a. For fee
   b. For future contract awards
   c. For subsequent product use

3. Most government agencies, and in particular the Air Force Flight Test Center (AFFTC) have chosen to use an independent evaluation of the product as the best performance evaluation mechanism.

B. DT&E/OT&E FLIGHT TESTS

1. Small but important part of the overall development cycle.

   a. Limited funding
   b. Driven by production schedules
   c. Driven by IOC dates
   d. Not a profit center for the firm

2. Flight Test Objectives

   a. Evaluate spec compliance
   b. Evaluate military utility
   c. Provide data for TOs
   d. Provide data for training simulators

3. Flight Tests as a Design Driver: Direct impact if independent evaluations recommend changes that are within contract scope or you have extra money. But, the Air Force uses its evaluations to point out deficiencies, not recommend design changes. Some examples are:

a. All FCSs
b. F-16 big tail
c. F-15 wing clip and stabilator snag
d. B-1B tail cone
e. F-16 WFOV HUD
f. F-16 Block 15 OFP
g. B-52 OAS Block II OFP

C. ADVANCED DEVELOPMENT FLIGHT TESTS: The concept is the same: the contractors do the advance concept development, and the Air Force evaluates contractor performance. Some projects are done in-house, but more as a fallout of specialized expertise and training requirements than by any specific plan to move Government into design business.

1. Objectives: Explore promising technologies investigated in research programs.

a. Low budget
b. Sponsors from Product Divisions are usually required
c. Technologies to be explored are specified. Examples are:

(1) TACT-111
(2) IFFC-15
(3) AFTI-16/AMAS
(4) AFTI-111

2. Flight Test as a Design Driver: Impact much more subtile. There is no direct link between flight test results and hardware/software design. Impact depends on:

a. Salesmanship
b. Seminars/Symposiums
c. Personal influence
d. Literature search
e. RFP tailoring

Remember: The Air Force does not design or produce weapon systems. This is not our function or the function of any Government agency in a free enterprise system. We evaluate contractor performance. We have chosen to do this with independent system performance evaluations. Because of this, we have developed some pockets of exceptional expertise in test and evaluation. But developing Government expertise is only useful to the extent that it serves to enhance our posture to evaluate contractor performance.

Philip F. Oestricher
Director, Flight Test General Dynamics
Fort Worth Division

"FLIGHT TEST AS A DESIGN DRIVER"

By

PHILIP F. OESTRICHER
DIRECTOR, FLIGHT TEST

GENERAL DYNAMICS
Fort Worth Division

INTRODUCTION

- IS FLIGHT TEST A DESIGN DRIVER?

- WE SEE THREE DISTINCT PHASES IN THE AIRCRAFT DESIGN PROCESS:

    1. PRELIMINARY DESIGN AND ANALYSIS
    2. FLIGHT TEST
    3. DESIGN REFINEMENT

- LET US CONSIDER EACH PHASE IN THE CASES OF:

    1. A PRODUCTION ORIENTED PROJECT
    2. A TECHNOLOGY DEMONSTRATION PROJECT

A PRODUCTION ORIENTED PROJECT

- DEFINITION: A PROJECT WHOSE AIRCRAFT IS EXPECTED TO BE PRODUCED/MODIFIED IN SUBSTANTIAL NUMBERS FOR RELATIVELY LONG-TERM USE FOR PURPOSES OTHER THAN RESEARCH/DEVELOPMENT/TEST OPERATIONS

- EXAMPLE: F-111

- PHASE 1: PRELIMINARY DESIGN AND ANALYSIS:

  1. The Emphasis Here Is Purely to Establish a Configuration which Meets the Operational Requirements at a Reasonable Cost

  2. No Compromises Will Be Made to Accommodate Flight Test Needs

  3. Flight Testing Functions (to Include Instrumentation) Are Expected to "Do Whatever Is Necessary" in Order to Accomplish Productive Testing in Phase 2

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A PRODUCTION ORIENTED PROJECT

- PHASE 2: FLIGHT TEST:

1. Here We Are Determining How Well the Designers and Engineers Met Their Phase 1 Objectives
2. We Are Identifying Shortcomings and Needed/Desirable Improvements, Evaluating Fixes, Etc
3. Relatively Minor Problems Have a Tight, Quick Feedback Loop Such That Modifications Can Be Made with Little or No Reinvolvement of Phase 1 Activities
4. Flight Test Is Now Driving Design Refinements
5. There Is Nothing New Here – This Has Been an Integral Part of Aircraft Development for many Decades

A PRODUCTION ORIENTED PROJECT

- PHASE 3: **DESIGN REFINEMENT:**
  - ✔ Now the Needed Changes or Refinements Are Being Incorporated
  - ✔ A Major Milestone in this Phase Is the Release of Initial Production Designs
  - ✔ Phase 3 Design Activities Frequently Feed Back into Further Flight Testing (Occasionally into Phase 1) and the Cycle Continues

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A TECHNOLOGY DEMONSTRATION PROJECT

- DEFINITION:. . . . . A PROJECT WHOSE AIRCRAFT IS EXPECTED TO BE PRODUCED IN VERY SMALL NUMBERS FOR RELATIVELY SHORT-TERM USE IN RESEARCH/ DEVELOPMENT/TEST OPERATIONS WITH NO PRODUCTION PLANNED

- EXAMPLE:. YF-16

- HISTORICAL NOTE:. . IN THE EARLY DAYS OF MANNED FLIGHT, ALL PROJECTS WERE TECHNOLOGY DEMONSTRATORS

- PHASE1:. . . . . PRELIMINARY DESIGN AND ANALYSIS:

    1. The Primary Emphasis Here Is Similar to that of the Production Oriented Project But with at Least One Major Difference – The Mission

    2. Because the Primary Output of the Program Is Data, Flight Test Instrumentation Becomes the Payload and its Requirements Must Be Carefully Considered in the Design

    3. Consideration of Flight Test Needs in Phase 1 Can Reduce the Time and Money Required to Complete the Program

    4. To Some Extent Flight Test Should Be a Design Driver

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A TECHNOLOGY DEMONSTRATION PROJECT

- PHASE 2: . . . . . FLIGHT TEST:

  1. Here We Are Evaluating (Much as with the Production Oriented Project) the Performance of the Design/Engineering Team in Meeting the Phase 1 Objectives

  2. The Technology Features of Special Interest Constitute Greater Technical Risk and, as Such, Are more likely to Drive Preliminary Design Refinements than in the Case of the Production Oriented Project

  4. Flight Test Is Definitely Driving Design Refinements

- PHASE 3: . . . . . DESIGN REFINEMENT:

  1. This Phase Is Not Radically Different from that of the Production Oriented Project Unless the Technology Features of Interest Fail or the Project's Technical Goals Are Redirected

  2. If the Project Objectives Are Redirected Toward Production (YF-16 to F-16A/B), Then This Phase Quickly Transitions to Phase 1 and Flight Test Needs Again Assume a Very Subservient Role

ISSUE

HOW CAN TIME AND MONEY BE SAVED BY FLIGHT TEST NEEDS DRIVING THE DESIGN?

- FOR THE PRODUCTION ORIENTED PROJECT, PROBABLY NOT AT ALL
- FOR THE TECHNOLOGY DEMONSTRATION PROJECT, MEANINGFUL SAVINGS ARE POSSIBLE IF FLIGHT TEST NEEDS ARE CONSIDERED THROUGHOUT THE PROJECT
- EXAMPLES OF SAVINGS IN THE YF-16 PROJECT:
    1. Inertial Reference Set Was a Converted Carousel IV which Proved to Be Inexpensive, Reliable, Accurate and Easy to Use. It Provided Velocities, Accelerations, Angular Rates, Etc. to the Data System
    2. Wing Fittings Were Overdesigned so that the Full 9g Structural Capability Was Available Without a Typical Loads Build-Up Program (80% of 125% = 100%)
    3. Since Testing Was to Be Done at Edwards AFB, No TACAN, VOR or Tailhook was Fitted
    4. Instrumentation Needs (Volume, Power, Cooling, Access, Etc) Were Considered Early in the Design Process. This Yielded a Very Versatile, Easily Maintained System Which Did Not Cause Any Significant Testing Delays
    5. The Fly-by-Wire Flight Control System Concept Allowed Quick System Refinement Through "Fine Tuning" of Gains, Lead-Lag Values, Etc. Often, the Determination of an Optimum Value Was Done on a Single Flight through the Pilot Selecting Various Options and Repeating the Run
    6. The Nature of the Flight Test Program (If It Is Carefully Considered) Will Often Allow "Off-the-Shelf" Equipment to Be Used to Same Cost (F-4 Nosewheel, B-58 Main Wheels, Sabreliner Nosewheel Steering, A-4 Ejection Seat – All on the YF-16) at No Loss in Testing Capability

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CONCLUSIONS

- FOR PRODUCTION ORIENTED PROJECTS, FLIGHT TEST IS A DRIVER ONLY AS REGARDS DESIGN REFINEMENT – THE MISSION REQUIREMENTS COME FIRST AND FLIGHT TEST HAS TO BE FLEXIBLE AND ACCOMMODATIVE

- FOR TECHNOLOGY DEMONSTRATION PROJECTS, FLIGHT TEST MUST BE CONSIDERED THROUGHOUT THE DESIGN PROCESS IN ORDER TO REALIZE THE MAXIMUM BENEFITS POSSIBLE – FLIGHT TEST IS A DESIGN DRIVER BECAUSE DATA ACQUISITION IS THE MISSION

- SIGNIFICANT SAVINGS OF TIME AND/OR MONEY ARE POSSIBLE IF FLIGHT TEST NEEDS ARE CAREFULLY CONSIDERED EARLY IN THE DESIGN PROCESS AS REGARDS TECHNOLOGY

James T. Johnson
757 Chief, Project Engineer
Boeing Commercial Airplane Company

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BY

JAMES T. JOHNSON, 757 Chief Project Engineer, and
S. LEWIS (LEW) WALLICK, JR., Director of Flight Test

This presentation discusses the inter-relationship between the design of Boeing jet transports and their flight test programs.

Special attention is given to cases where introduction of new technology requires a change to the procedures of flight testing and cases where flight testing has caused modification to the design of air transports.

After a presentation of the most recent Boeing flight test program, which involves the 757 and 767 airplanes, it concludes with a discussion of the design implications for the next generation jets.

S. Lewis (Lew) Wallick, Jr.,
Director of Flight Test
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